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Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of

An Inquiry into the Commission's Policies and Rules Regarding AM Radio Service Directional Antenna Performance Verification

MM Docket No. 93-177

RM - 7594

Comments of Radiotechniques Engineering Corp.

Radiotechniques Engineering Corp. (herein "Radiotechniques") hereby submits its comments in response to the Notice of Inquiry in the above referenced proceeding. Radiotechniques has provided technical services to the broadcast industry since 1979.

I. *Introduction*

Radiotechniques recognizes and applauds the Commission's initiative in revamping an area of regulation that evolved piecemeal over many years without a comprehensive review. Regulation changes should correspond with changes in the state of the art and state of the industry. AM directional antenna regulations originated many years ago, and do not consider the advantages of computer analysis, and advances in design synthesis. Regulation of AM directional antennas has precluded AM broadcasters from adjusting to the changing marketplace. Regulation has made it impossible for AM station owners to market tower space on their radiators. In other cases, AM broadcasters who find it impossibly expensive to comply with rules simply ignore or violate them and hope that their actions are not discovered.

There are several observations that these comments consider:

1. The AM licensee is generally not technically knowledgeable.

2. The technology to adequately monitor an AM directional antenna is available.

3. The technology to adequately analyze AM directional antennas is available.

4. There is often little money available in AM stations to correct problems in AM directional antenna systems.

5. The cost of complying with some regulation is considered by some licensees to be greater than the probable cost of fines for violation of those rules.

6. Horizontal plane measurements do not reliably predict antenna performance above the horizon.

7. There are few practitioners qualified to adjust and verify complex directional antennas.

There are several principles that these comments support:

1. AM directional regulations must provide affordable compliance.

2. Regulation of AM directional antennas must be based upon the actual needs of the industry for protection of other stations.

3. Regulation of maintenance of AM directional antennas should be as simple as possible, and provide the tools for a licensee to know with a reasonable level of certainty that the antenna system complies with the requirements.

4. Much less measurement data are now needed because the use of computer and statistical analysis in verifying performanc e of AM directional antennae make better use of the data.

5. The revised regulations must protect the AM broadcaster from the danger of having its ability to broadcast jeopardized by construction adjacent to its directional antenna.

II. *Overview*

The AM broadcasting service is in a sorry state. AM broadcasters abetted by receiver manufacturers succeeded, during the late 1960's, the 1970's and 1980's, in decreasing the quality of the AM product so much that AM became synonymous with "poor quality." Too many commercials, loudness wars, and abysmal receiver performance, along with increasing noise levels from computers, burglar alarms, light dimmers, and High Voltage power lines made listening to AM radio a chore.

Once high performance FM radios became available at low cost AM radio became a pariah. An entire generation now does not even recognize that AM radio exists. There will remain major AM stations that will remain very successful due full market coverage, and intelligent programming. AM stations can succeed in hilly areas where FM does not cover the entire market. AM stations can also be successful in smaller markets where there are only few programming choices. It is our opinion that AM radio will remain a second class medium that can generate profits in niche markets, finance, sports, news, talk, oldies, big band, religion, foreign language/culture, etc.. AM stations which do not provide full market coverage are, we think, destined to eventual failure.

If medium wave digital radio can be developed, then there may be a resurgence of former AM stations, but only for stations with full market coverage. The present rules make it very difficult for AM stations to re-establish full market coverage. The cost of complying with the proof of performance rules makes changes to optimize the signals of an AM station out of reach for all but the most profitable stations. The majority of the work in AM that this office has seen since the freeze was lifted is in allocations studies to determine if the present antenna sites can be wholly or partially sold for development. Any signal improvements are secondary , and signal loss is often an acceptable option.

There are several improvements in the art that have become technologically possible, but present regulation, and the poor economic situation at AM stations inhibit their use.

The most significant of these is the utilization of *Method of Moments* analysis and synthesis of antenna arrays. It is essential that the Federal Communications Commission recognize the value of these codes as a valuable tool in analysis and synthesis of AM Directional antennas. Some of the problems in setting up regulations that recognize these codes is that there are several different codes in existence which are each optimized for different purposes. The codes remain approximations (although much more accurate than sinusoidal distribution) because of finite segment length, the fact that transverse currents are

not evaluated, and the potential for round off errors. Even at its worst, a reasonably well selected code with a reasonably well crafted model is more accurate than sinusoidal distribution. International regulations additionally codify the use of the *standard pattern* for allocations purposes.

The design of antenna systems can be configured in many different variations than that assumed by the rules. The present rules assume a *common point* of power input. Much broader bandwidth antennas can be configured using dissipative loads installed at various places in the antenna system. Passively driven elements of an antenna system are technically practical, but not permitted under current policies. The common point power measurement method makes this method of stabilizing and broadbanding antennas unattractive or impossible.

Digital transmitters can have multiple output amplifiers at each tower base with a common exciter that would synchronize each of the amplifier's power and phase. This would eliminate the high cost of transmission lines and complicated, custom designed phasing and branching circuitry. Automatic antenna coupling units can dynamically adjust to compensate for weather related shifts in antenna impedance.

Antenna monitoring systems can use wireless methods of comparing the amplitudes and phases of the various antenna parameters, but the rules for monitors assume that there is a coaxial cable installed from the sampling device to the antenna monitor.

Antenna structures can be optimized in their structural configuration[1] for improved night performance, but the present rules do not consider this factor. (Curved and slanted radiators)

AM directional antenna systems are disrupted by construction of other structures in the radiated field that may reradiate the signals. The licensee has no control over the approval of

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[1] *MF AM transmitting Asymmetric Vertical Dipole,* Valentin Trainotti, IEEE Transactions on Broadcasting, Vol 37, No 3., P 106-114, Sept 1991

these constructions. The traditional method of dealing with towers, etc. is to detune them, at considerable expense, and re-proof the antenna system at considerable additional expense. At night, there is little assurance that detuning structures is an appropriate mitigation for these disruptive effects.

III. Suggested Rulemaking Actions and Areas for Further Study

§73.14 The definitions of Antenna Current, Antenna Input Power, Antenna Resistance, Critical Directional Antenna, Input Power, Last Radio Stage, and Nominal Power will all be affected by changes in these rules.

§73.33 This rule is generally worded, but the definition of what makes up a proof of performance should be changed in this rulemaking.

§73.45 (a) Radiotechniques believes that minimum efficiency is an idea which is now counterproductive. We believe that the considerations in regulating AM antenna systems are guaranteeing principal city service, and assuring that the directional antenna field intensities do not exceed the maximum values authorized in its instrument of authorization. Low theoretical efficiency may be due to losses in the antenna system or an antenna with high radiation values at angles well above the horizon. Losses in the antenna system are beneficial to antenna stability.

Antenna systems with high radiation angles are a problem only if the radiation causes interference to other stations, or to the groundwave service of that station. High values of radiation at high angles do not effect the daytime operation of stations (with the exception of expanded band, due to the early formation of skywave). Night operation can be effected by high angle radiation due to self interference, or by interference to other stations. AM allocations rules presently adequately protect other stations from interference. There needs to be an analysis of self interference (fading) if night operation is permitted with antennas with high values of high radiation.

Sections (a)(1) and (a)(2) simply restate §73.33 and should be deleted.

If antenna efficiency is deregulated at the proof of performance stage there is a potential for abuse. Unfortunately, some unscrupulous practitioners might make a misadjusted antenna "meet FCC requirements" by introducing losses in the system to reduce fields. This problem is similar to where some FM Stations operate at reduced output power with dud tubes or defective transmitters, but meet the rule requirements of minimum power by tuning the transmitter for low efficiency to make the indirect power comply with FCC rules. We believe that *caveat emptor* should prevail, where the broadcaster should utilize qualified engineering personnel, and the FCC leave the problem to the marketplace.

Section (b)(2) should be deleted.

Section (c) is appropriate if the station is using an antenna ammeter or common point ammeter. Whenever a station uses a direct reading power meter, there is no need for using indirect method during construction or modifications, since these devices accurately measure power in differing loads.

§73.51 The preferred method of power measurement should be via a direct reading power meter. Antenna impedance can vary for many reasons. Most antenna phasing equipment has front panel controls that adjust common point resistance. Inadvertent manipulation of these controls will cause an inaccurate power indication using an RF Ammeter.

Section (b) should be completely rewritten to take dissipative loads at various points in an antenna phasing system and distributed transmitters into consideration.

Section (c) should be completely rewritten to accommodate low efficiency antennas.

Section (d) appears appropriate.

Sections (e) and (f) should be modified to consider configurations with multiple final radio stages, and consider new high efficiency amplifiers with F over .90.

§73.53 Antenna monitor type approval is appropriate for these devices. This rule should anticipate the use of wireless antenna monitors that do not use coaxial cables for sampling the antenna element signals. This would require rewording of sections (b)(7) and (b)(8).

Section (b)(7) should allow simultaneous display of the amplitude and phase information for all inputs.

Section (b)(9) should provide for preset limits and an alarm instead of meter indications for remote or extension operation.

Section (b)(11) should have provisions for higher accuracy specification as an optional type approval. Section (c) should be deleted.

§73.54 This rule should apply only for those stations that do not use a direct reading power meter.

Section (b)(2) should be deleted, since many transmitters operate best into a load with a small reactive component. Permitting a reactive component at the common point also allows the adjustment of the antenna impedance to equal that of the station dummy load.

The measurements in section (c) should be replaced with a single measurement at carrier if made with more than 100 Watts using an Operating Impedance Bridge. The requirement for multiple measurements is needed only to decrease the uncertainty caused by interference when using a low power bridge. When using a low power bridge, there is no value to making bridge measurements at frequency deviations more than 10 kHz above or below the carrier frequency.

Section (d) is redundant. The station operating resistance is filed with the licence application, or in the case of direct reading power meters is irrelevant. If the method of power measurement changes, or if the resistance changes and direct measurement using antenna

current measurement, then an FCC form 302 direct measurement application should be filed. If the methods of making the measurements are defined in the rules, then only the location of the point of measurement should be maintained at the station. This could be done by labeling the location, instead of putting it in a file. This rule should establish methods for calibration of impedance measurement equipment.

When multiple points of power measurement are specified, each shall be similarly identified.

Section (e) gives no guidance for the case where a station has a direct power measuring meter, and chooses to replace it with an ammeter.

§73.57 This rule section is unduly complex. Section (a)(1), (a)(4), and (a)(5) along with section (c) describe permitted acceptable main antenna meters, and should be deleted. Main antenna power meters (and current meters) may be digital. Where the measurement data are maintained in digital form, there is no ability or requirement for separate calibration of the remote device.

§73.58 Section (a) is reasonable as written. It may be desirable to delete the requirement for the ability to measure power by the indirect method when the transmitter has installed within it a direct power measuring instrument meeting the requirements of §73.1215.

Section (b) must be deleted. The thermocouple type ammeter may be the single most unreliable and inaccurate device in the directional antenna system. New installations should not permit thermocouple type ammeters in unheated tower buildings. Base currents are unreliable indicators of antenna operating parameters for towers approximating 180 degrees in electrical length, since electrostatic effects can cause wide variations in base current in these towers while the antenna radiation effects are largely unaffected. Meters at the base of each tower should be optional, and maintenance of base current ratios should not be required.

Section (c) is unnecessary since §73.54 covers this condition.

Section (e)(1) should be deleted.

Section (e)(2) should include direct reading power meters.

§73.61 The entire use of monitor points should be reviewed in depth. Each radial that would normally be assigned monitor points should have several locations, each of which have been previously measured which can show correct operation. Far too often the monitor point that was chosen at the time of the proof of performance is spoiled by construction or access difficulties. Any reasonable previously measured location should be able to be substituted for the initial point chosen without doing a lot of paperwork.

Section (b) and (c) refer to partial proof of performances. These measurements and the resulting analysis are beyond the means of many stations to complete under the terms of this rule. We believe that many stations operate outside the conditions of their license due to the excessive expense of conducting a partial or complete proof. If these measurements would cause a station to become unprofitable or insolvent, the licensee may ignore the out of adjustment condition and hope not to get caught.

§73.62 This paragraph should remove all references to base current ratios. Section (b) opens a station to double jeopardy since the condition of inclement weather that caused the variation of parameters may make it difficult or impossible for station personnel to reach the monitor points to find out if they are within authorized limits. Section (b) should provide that during the 10-day period the monitor point indications need not be maintained while the inclement weather persists.

§73.68 This rule section is well crafted, however, provisions for wireless sampling systems should be included. The FCC should provide a deadline after which all sampling

systems must comply with this rule. Since these comments propose an increased reliance upon sampling systems and antenna monitors, certain additional requirements are proposed.

Section (a)(2) should be changed to "Sampling lines for directional antennas may be of different lengths provided variation in the phase differences of signals at the monitor are less than 0.5 degrees (or .16 times the tolerance for phase specified in the instrument of authorization) when the lines are exposed to the highest and lowest temperature variations to which the system is expected to encounter. The electrical length of the lines shall be measured upon installation, and this information maintained in the station file. "

A new Section (a)(4) should be added which requires that sample lines shall have solid outer conductor, be installed so that they are protected from inclement weather, corrosion and mechanical damage, use connectors that are designed for the specific type of line used, and that the characteristic impedance of the line is the same as that of the terminating resistor in the antenna monitor.

A new Section (a)(5) should be added. All sample lines shall be of the same type upon initial installation, and replacement of any line shall be made using either the same type of line or one with the same nominal diameter, impedance, conductor material, and velocity factor as the remaining lines in the system. When a sample line is replaced or repaired its electrical length shall be measured and the information maintained in the station file.

Section (d)(2) should delete reference to base current ratios, and provide that replacement of antenna sampling system components with identical replacements where the antenna monitor readings remain within the tolerances specified on the instrument of authorization may be accomplished without notification to the FCC. Additionally the section after "specified in the instrument of authorization or the pertinent rules." should be deleted.

Section (d)(3) should be modified to "If that portion of the sampling system of the towers is modified or components replaced with other than identical replacement units (ie. Manufacturer, part number, dimensions, and additionally in the case of sample line, electrical

length) then performance verification in accordance with §73.154 is required subsequent to these changes."

Section (d)(4) should contain only the present first sentence with the following phrase appended: "if the operating parameters for the antenna system are changed from the values specified in the instrument of authorization." A replacement of sampling system components generally should not cause a change in the antenna monitor values, or the common point impedance.

§73.69 Section (a)(1) is unduly detailed. Substitute: "The antenna monitor shall be installed so that the environmental conditions to which it will be exposed under normal conditions will not exceed the limits under which it was type approved.

Section (b) duplicates §73.68 (c) and should be deleted.

§73.151 This section needs complete revision. The present rule does not take into consideration the ability to verify performance at much closer distances using method of moments, or more simply parallax correction methods. The present rule is unduly complex, expensive to comply with, and includes much unnecessary data.

Reradiation by structures near AM directional antennas:

Structures near AM directional antennas may disrupt the directional pattern of the station to potentially cause interference to other stations. The Commission must balance the protection of stations from interference with the need to protect AM broadcaster from the possibility of losing his site by the construction of structures not within his control.

Reradiating structures can cause the nominally circular patterns of omnidirectional AM stations disrupted to the extent that the signal in some directions is nearly double the licensed

RMS intensity, and a small fraction of the RMS intensity in other directions. This potential for interference is ignored in the rules.

Reradiating structures can, at considerable expense, be detuned to mitigate the effect of the structure on the horizontal radiation pattern. Reradiating structures greater than one half wavelength in size, or more than a few wavelengths from the array will have greatly different effects on the horizontal plane pattern and upon patterns above the horizon. Our opinion is that the effects of detuning large structures more than two or three wavelengths from an antenna array to is probably counterproductive unless the protections provided by the array are nearly at the horizon. Considering the above, we recommend that structures more than a few wavelengths from the array should not be detuned in nighttime directional antenna systems.

If directional antenna parameters are "jimmied" to compensate for the effects of reradiation on the horizontal pattern the high angle radiation pattern will be further disrupted, and the removal of the reradiator will cause the effects of the mistuning to be evident. We believe that it is be better to adjust the array to predicted values than to "jimmy" an array to compensate for reradiation.

Since omnidirectional antennas can potentially radiate up to two times the licensed field in certain directions, equity says that directional stations should be given a similar margin. For nighttime low angle or groundwave protection the effects of reradiation should be overlooked if the sum of fields from the reradiator and the directional antenna are less than 170%[2] of the standard pattern field.

The effects of reradiators on a directional antenna pattern are dependent upon certain parameters:

1) The incident near field magnitude on the reradiator.
2) The amount of desired signal suppression of the directional antenna.

3) The conditions of resonance of the reradiator.

4) The antenna area of the reradiator.

5) Conditions of symmetry between the areas of suppression and the location of the reradiator (important for detuning)

Stations with simple antenna systems - which we would define as those constructed using identical simple omnidirectional radiators, without sectionalization or detuning skirts, or multiple drive points; RSS/RMS ratio of less than 2.0[2]; and null depth no less than 10%[2] of RMS field.

Provided the station constructs the antenna system using an approved sample system as described herein, and sampling devices are identical, or are calibrated with relative amplitude sensitivity and phase offset. We propose that it is adequate to merely adjust the antenna system to the values predicted by method of moments, and conduct no field measurements. The showing then would be to show the offset calculations between the theoretical parameters in the construction permit, and the values shown on the antenna monitor.

Stations with toploaded antennas must measure the current distribution of the antenna to verify that it approximates the predicted current distribution.

Stations with complex antenna systems:

The license application should include the information above plus information to show that the antenna produces the desired horizontal field intensity. We believe that these procedures are adequate to show such performance:

Establishment of the effective field on nulls, and minor lobes with $E_{Standard}$ below the $RMS_{Standard}$ and in the direction of the principal community. If an unusual antenna

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[2] The values chosen herein are reasonable first estimates, and not considered to be final.

configuration is specified which may produce an $RMS_{Measured}$ in excess of the $RMS_{Standard}$ and the additional field could cause interference to another station, then the FCC may require additional radials to establish the measured field in the appropriate directions.

The phase difference and sign of the current at the sample point in each element with respect to the reference element.

The ratio of the amplitude of the current at the sample point in each element with respect to the reference element.

The predicted current distribution (amplitude and phase) for each element, showing the sample point for that element.

For top loaded towers, sectionalized towers, towers with elevated ground systems or for towers of unusual cross section, or where the current distribution for purposes of initial authorization was assumed to be other than sinusoidal, current distribution measurements on the tower.

Descriptions of several field measurement point locations on each radial for which measurements were taken sufficient to uniquely identify the place where the measurement was taken.

Section (b) of this rule can be deleted since the requirements of the rule would now be sufficiently straightforward that this section is an unnecessary exception.

§73.152 This rule may be difficult to change because it repeats technical characteristics of international agreements.

Section (c)(2)(iv) should be modified to change the ending to read: "and shall not exceed 120%[2] of the actual measured inverse field value." Subparagraphs (A) and (B) can then be deleted.

§73.153 This rule should be rewritten to describe the measurements necessary to determine ground conductivity or to determine inverse field in a given direction. It should not point to §73.186 but stand on its own.

§73.154 The partial proof would only be used for stations that wish to reference measurements to a full proof performed under prior rules, or wish to use non computer assisted measurement analysis.

§73.158 These comments propose multiple monitoring points per radial to eliminate the requirement to change points when conditions change at any one point.
This rule should be rewritten to require the currently used point to be within limits arithmetically set in the proof.

§73.186 We do not understand why this rule was not the primary target of the rulemaking. The methodology of this rule is archaic and does take improvements in statistical analysis and near field estimation in consideration.

General Principles:

1) No measurements further than 35 wavelengths or 50 times the maximum distance between the reference and the most distant tower from the reference (Whichever is greater) from the station should be required.
2) All measurements shall reference an assumed ground conductivity equal to the value for the site on figure M-3, to conductivity determined on previous measurements made on the same antenna system and usable over an arc up to 10 degrees either side of the measured radial, or concurrent measurements on a non directional tower, which is

an active tower in the directional array to be measured. These references are in increasing order of priority.

3) Non-directional measurements may begin at one wavelength from the reference tower, directional measurements may begin at two times the differential distance between the furthest tower and the reference tower

4) All measurements shall be proximity corrected for near field effects.

5) All measurements locations shall be verified using Global Positioning System (differential where available)

6) A minimum of five directional measurements, and seven non-directional measurements shall be made.

7) If the standard deviation of the ratio of directional to non-directional reference exceeds 10%[2] of the standard field, then additional measurements should be made.

8) The methods presently in required should continue to be authorized for those who wish to use them.

9) There is no need to provide to the FCC or keep in the station file maps, polar plots, GWFI curves with proof of performance data.

Analysis of Data:

Unattenuated field shall be determined by the following procedure:

Calculate the near field at the distance and direction from the reference tower for infinitely conducting plane earth in microVolts. Add in quadrature, a term equal to the standard pattern "Q" value adjusted for inverse square distance. Convert the result to dbμ V.

Subtract the attenuation in db (in excess of inverse square law) for the appropriate frequency, ground conductivity, and dielectric constant using the methods which are used to generate the curves of §73.184 from this value. Ratio the measured value of field intensity at this point (in dbμ V) with the calculated value.

Repeat this process for each measured point on the radial. Take the antilog of the average of these ratios. If the standard deviation of the antilog of the individual ratios is less than 0.1^2, then the evaluated unattenuated field on the radial is equal to the standard pattern unattenuated field times the antilog of the average ratio.

If the standard deviation exceeds 0.1^2 then there may be inadequate data to evaluate the unattenuated inverse field. This may be due to the scattering effects of reradiating structures, or variations in earth conductivity and dielectric constant that have not been accounted for. Additional data points are needed, and/or the reference data needs to be upgraded (from M-3 to previously measured, or non-directional measurements at the same points as used in the directional analysis)

The non directional field used may be that established by measurements according to the present rules, the value found by the chart on §73.190 Figure 8 or, in the case of antennas that are not simple omnidirectional directional vertical antennas with conventional buried ground systems, the value that provides a best fit of the data to the attenuation curves.

§73.189 Minimum efficiencies should be eliminated, with the exception of class A stations that must operate at 50 kW, and provide a minimum level of service.

Conclusion

FCC rules regarding AM Radio Service Directional Antenna Performance Verification should be modified to simplify, clarify and make compliance more economically affordable.

1. Simple directional antennas may be adjusted to the desired parameters without field verification.
2. Proof of performance field measurements for complex antennas may be much fewer and made at shorter distances from the station if appropriate analysis techniques are used.

3. The standards for sampling systems must be more stringent to assure that the measurements of antenna parameters actually indicate proper operation of the antenna system.

4. Minimum efficiency for AM antennas is counterproductive to the development of new low profile antennas and dissipative bandwidth and stability enhancement methods.

5. Moment of Methods should be recognized as an accurate method of analyzing antenna systems.

6. Thermocouple meters should be banned from antenna bases.

7. Provisions for new ways of accomplishing sampling and feeding of antennas should be facilitated by the revised rules.

8. Reradiating structures more than a few wavelengths from a night antenna should not be considered as disruptive of high angle radiation just because it disrupts the horizontal pattern beneath the required protection. These structures should not generally be detuned. Reradiation should be permitted to increase the field intensity on a radial by some margin, to less than 200% of standard pattern field.

9. Where field monitoring points are required on a radial, any documented measurement point on the radial may be used without FCC authority.

10. Plots and maps should not be required to be submitted or kept in the station records. GPS should be used in conducting field measurements.

11.i Impedance measurements, made at substantial power need only to be made at the carrier frequency. Measurements at low power need only to be made up to ±10 kHz from carrier frequency.

Respectfully submitted,

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